

Chapter VIII

EXPOSURE INDEX DEVELOPMENT

A potential link of clinical end points with herbicide exposure can be tested within the Ranch Hand cohort by using a measure of exposure (exposure index). In general one would search for increasing indications of illness at higher levels of exposure. However, exceptions to this assumption of a consistently increasing dose-response curve are possible through a variety of bio-medical mechanisms.

The exposure index used in this report relates to the TCDD-containing herbicides: Herbicide Orange, Herbicide Purple, Herbicide Pink and Herbicide Green. Archived samples of Herbicide Purple suggest that the material had a mean TCDD concentration of approximately 33 ppm and that Herbicide Orange had a mean concentration of 2 ppm. Herbicides Pink and Green contained twice the TCDD of Herbicide Purple and therefore have been estimated to contain TCDD at a concentration of approximately 66 ppm.

The index used in this report is written below:

$$E_i = \left\{ \begin{array}{l} \text{TCDD} \\ \text{Weighting} \\ \text{Factor} \end{array} \right\} \times \left\{ \begin{array}{l} \text{Gallons of TCDD-} \\ \text{Containing Herbicide} \\ \text{Sprayed in the RVN} \\ \text{Theater During the} \\ \text{i}^{\text{th}} \text{ Subject's Tour} \end{array} \right\} \times \frac{1}{\left\{ \begin{array}{l} \text{Number of Airmen with Subject's} \\ \text{Duties in the Vietnam Theater} \\ \text{during the i}^{\text{th}} \text{ Subject's Tour} \end{array} \right\}}$$

The TCDD Weighting Factor is 24.0 or 1.0, depending on whether the material sprayed was sprayed before or after 1 July 1965. The weighting factor of 1 is used for the period after 1 July 1965, as the HERBS TAPE and other documentation (Young et al, 1978) show only Herbicide Orange being disseminated by Air Force-flown, fixed-wing aircraft at that time. Prior to 1 July 1965, procurement records and dissemination information show that a combination of Green, Pink and Purple was procured and sprayed by Air Force individuals in Vietnam. Using available data (Young et al, 1978) on gallons of Green, Pink and Purple procured and sprayed, a mean of 48.0 ppm was established for the time period prior to 1 July 1965. Dividing by 2 to normalize to Herbicide Orange, the weighting factor becomes 24.0 (i.e., 48/2 = 24/1).

The dates of each subject's tour(s) in the Republic of Vietnam were determined by a manual review of military records. The HERBS TAPE was used along with Contemporary Historical Evaluation and Combat Operations (CHECO) Reports and quarterly operations reports to construct a table of gallons of TCDD-containing herbicide sprayed for each month during the operation. These data are shown in Table VIII-1. For Herbicide Orange missions actual gallons are shown; while for Herbicides Purple, Pink and Green the factor of 24.0 is already

included making these effective Herbicide Orange or equivalent Herbicide Orange gallons (TCDD at 2 ppm). The CHECO Reports and quarterly operations reports were used in addition to the HERBS TAPE, as the HERBS TAPE currently available does not list all pre-1965 spray missions. Again, only fixed-wing spray missions are compiled in Table VIII-1, as Ranch Hand personnel were not involved with helicopter and other spraying (e.g., backpack). Also provided in Table VIII-1 are Ranch Hand manning in each occupational category by month, as derived from a review of military records. A computer program was written to address this table with each subject's tour dates to the nearest month, to calculate his exposure index in effective or equivalent Herbicide Orange gallons.

The exposure index reflects the effective number of gallons of Herbicide Orange to which the airman was potentially exposed, where exposure to the higher TCDD-containing herbicides (Purple, Pink, Green) has been properly weighted to place them on the same footing as Herbicide Orange.

As seen by examining the above index definition, the index developed should correlate with the individual's exposure but cannot be an exact measure of actual exposure or body burden. The index is an estimate only, since TCDD concentration is known to have varied across herbicide lots, and since the index does not reflect exceptional exposures such as aircraft hits by enemy fire or dumps (these events are essentially assumed equally distributed). Additionally, the index reflects potential exposure only and does not address specific and determining details of the actual contact. While the index certainly contains errors when applied to judge the exposure of a specific individual, in studying groups of individuals epidemiologically, as in this report, these individual errors are expected to balance out or statistically cancel to a great extent, providing some degree of useful inference.

The numeric exposure index calculated by the procedure described above was subsequently categorized into 3 levels (Low, Medium, High) for use in statistical analyses; and, this categorization was accomplished in a different manner for each Ranch Hand occupational category in order to optimize study capability to detect a herbicide effect. Details of the exposure categorization are as follows.

The study design called for 5 occupational categories: (a) officer-pilot, (b) officer-navigator, (c) officer-other, (d) enlisted-flying, and (e) enlisted-ground. For all exposure index analyses presented in this report, only 3 occupational categories are employed. Specifically all officers were combined into 1 class titled "officer". This combination was accomplished since navigators and pilots were exposed in the same manner, and since individuals in the "officer-other" category were administrators whose exposure was considered effectively zero. Additionally, in the enlisted-ground group, all administrative personnel were assigned a zero exposure value. Under these basic rules, the categorizations shown in Table VIII-2 were developed. A very balanced membership in each occupational category has been provided for each exposure level, optimizing statistical ability to detect a herbicide effect if one exists.

Table VIII-1

HERBICIDE ORANGE EQUIVALENT GALLONS AND RANCH HAND MANNING BY MONTH

<u>Mo/Yr</u>	<u>Gallons Sprayed</u>	<u>Pilot (Occ 1)</u>	<u>Navigator (Occ 2)</u>	<u>Other Officer (Occ 3)</u>	<u>Flying Enlisted (Occ 4)</u>	<u>Other Enlisted (Occ 5)</u>
10/61	0	0	0	0	0	0
11/61	0	5	1	1	6	14
12/61	0	9	2	1	7	20
01/62	191426	14	2	1	7	23
02/62	324216	14	2	1	7	23
03/62	191426	15	2	1	7	20
04/62	0	16	2	1	6	14
05/62	0	15	3	1	6	13
06/62	0	12	2	0	5	7
07/62	0	13	2	0	5	4
08/62	0	11	2	0	5	5
09/62	334126	12	2	0	5	6
10/62	334126	9	1	0	5	6
11/62	0	10	0	0	5	5
12/62	90879	8	0	0	4	5
01/63	0	9	0	0	5	4
02/63	0	7	1	0	5	4
03/63	0	12	1	0	5	6
04/63	0	12	1	0	5	6
05/63	0	10	1	0	5	7
06/63	174024	10	1	0	4	7
07/63	259150	11	1	0	8	6
08/63	0	8	0	0	8	4
09/63	0	10	1	1	9	4
10/63	339588	7	1	1	9	6
11/63	377172	6	1	1	10	6
12/63	942630	5	1	1	6	6
01/64	121454	7	1	1	7	5
02/64	363758	5	1	0	7	4
03/64	755312	8	1	0	5	4
04/64	56799	9	1	0	6	2
05/64	152271	10	2	0	5	2
06/64	612709	7	3	0	5	2
07/64	282789	9	3	0	6	3
08/64	777669	9	3	0	5	3
09/64	1413945	8	3	0	4	2
10/64	1413945	9	3	0	4	2
11/64	1413945	11	3	0	4	1
12/64	1413945	10	3	0	6	1
01/65	1296116	11	4	0	6	1
02/65	1437510	12	5	0	6	1
03/65	730538	13	4	1	6	1
04/65	659841	14	3	1	6	2
05/65	1767431	15	4	1	6	2
06/65	0	16	4	1	7	4
07/65	942630	19	4	1	7	3
08/65	26500	19	4	1	7	3
09/65	44650	22	4	1	6	3
10/65	78850	23	4	1	6	6
11/65	106900	24	6	1	10	12
12/65	148525	23	5	1	11	12
01/66	152450	21	6	1	10	16
02/66	129150	22	6	1	10	26
03/66	135600	21	4	2	10	32
04/66	141050	22	5	2	10	37
05/66	183900	21	6	2	9	38
06/66	191830	20	6	2	10	41
07/66	112300	21	8	2	9	45
08/66	192050	26	8	2	11	46
09/66	213970	28	9	2	12	62
10/66	122040	34	8	3	16	85
11/66	164800	41	8	4	18	104

Table VIII-1 (Cont'd)

HERBICIDE ORANGE EQUIVALENT GALLONS AND RANCH HAND MANNING BY MONTH

Mo/Yr	Gallons Sprayed	Pilot (Occ 1)	Navigator (Occ 2)	Other Officer (Occ 3)	Flying Enlisted (Occ 4)	Other Enlisted (Occ 5)
12/66	212100	45	9	5	28	123
01/67	202360	49	9	5	28	123
02/67	363830	59	13	5	28	116
03/67	285400	51	13	4	28	114
04/67	208300	50	14	4	33	108
05/67	251320	53	15	4	34	101
06/67	335860	55	13	3	36	105
07/67	253884	51	15	3	37	163
08/67	162895	63	13	4	32	160
09/67	298615	60	18	5	33	161
10/67	265335	55	19	5	36	149
11/67	372425	55	17	6	33	145
12/67	383605	58	18	6	34	129
01/68	333595	54	19	6	33	127
02/68	27450	65	19	6	35	141
03/68	48200	69	20	5	34	160
04/68	307740	72	20	6	36	161
05/68	336300	75	18	6	32	160
06/68	226325	77	18	6	37	164
07/68	258100	84	19	7	42	187
08/68	289160	91	18	9	45	192
09/68	216300	89	22	8	44	147
10/68	72250	89	20	8	49	155
11/68	189100	101	17	7	53	153
12/68	218750	94	17	8	51	154
01/69	264450	98	19	7	51	154
02/69	197450	91	18	5	51	166
03/69	356500	90	17	5	53	172
04/69	339800	94	20	6	54	161
05/69	353800	93	19	6	54	151
06/69	383533	88	19	7	57	155
07/69	287425	91	16	6	55	152
08/69	299100	85	16	6	55	155
09/69	206800	83	15	6	61	142
10/69	181000	83	17	6	61	122
11/69	205100	90	16	6	60	118
12/69	276900	76	16	5	52	114
01/70	186350	66	15	5	54	116
02/70	152100	58	15	5	41	122
03/70	153730	59	13	5	39	125
04/70	45700	54	13	5	37	109
05/70	0	51	14	5	29	94
06/70	0	47	14	3	18	84
07/70	0	44	11	2	16	74
08/70	0	40	9	1	14	63
09/70	0	40	7	1	13	43
10/70	0	34	6	1	14	37
11/70	0	30	5	1	15	35
12/70	0	25	4	1	13	30
01/71	0	23	4	1	14	28
02/71	0	23	4	1	14	28
03/71	0	23	4	1	14	28
04/71	0	23	4	1	14	28
05/71	0	23	4	1	14	28
06/71	0	28	4	1	14	28
07/71	0	29	4	1	14	28
08/71	0	29	4	1	14	28
09/71	0	29	4	1	14	28
10/71	0	29	4	1	14	28

Table VIII-2

EXPOSURE INDEX CATEGORIZATION

<u>Occupational Group</u>	<u>Exposure Category</u>	<u>Effective Herbicide Orange Gallons Corresponding to Exposure Category</u>	<u>Number of Ranch Hand Participants in Exposure Category</u>
Officer	Low	≤ 35,000	140
	Med	35,000 - 70,000	150
	High	> 70,000	151
Enlisted-Flying	Low	≤ 50,000	67
	Med	50,000 - 85,000	70
	High	> 85,000	66
Enlisted-Ground	Low	≤ 20,000	185
	Med	20,000 - 27,000	186
	High	> 27,000	207